# Virtual Flight Demonstration of Stratospheric Dual-Aircraft Platform

Completed Technology Project (2015 - 2016)

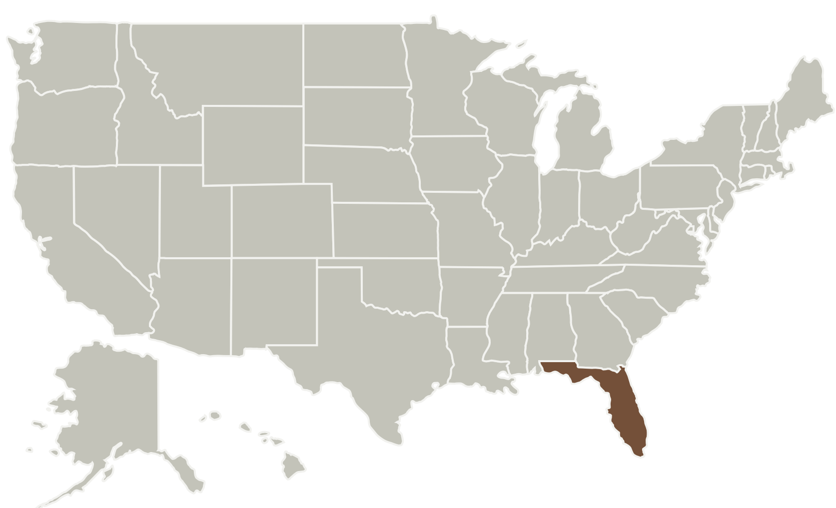
## Project Introduction

The Dual-Aircraft Platform (DAP) is a patented concept for achieving a low-cost atmospheric satellite which utilizes wind shear as the primary energy source, and has the potential to stationkeep without a substantial energy storage system. DAP consists of two glider-like Unmanned Aerial Vehicles (UAVs) connected via a thin, ultra-strong cable which literally sails without propulsion, using levels of wind shear commonly found in lower Stratosphere (e.g., near 60,000-ft). The two aircraft are positioned at different altitudes, as far as 3,000-ft apart, to encounter substantially different wind velocities. The device operates similar in principle to a kite-surfer in which the upper aircraft, referred to as the SAIL, provides lift for both aircraft and aerodynamic thrust, while the lower aircraft, known as the BOARD, provides an upwind force to keep the platform from drifting downwind. Each aircraft extracts additional energy via solar film and possibly a wind turbine to operate the avionics, flight controls, payload, and for intermittent use of propulsion.

## Anticipated Benefits

Communication relay (e.g. remote Internet, emergencies); Earth remote sensing; Surveillance; Constellation to support NAS; DAP expected to offer much more power to payloads than a pure solar aircraft

## Primary U.S. Work Locations and Key Partners

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| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Embry-Riddle Aeronautical University-Daytona Beach | Lead Organization | Academia | Daytona Beach, Florida |

| Primary U.S. Work Locations |
|---|
| Florida |

## Project Transitions

**July 2015:** Project Start

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Embry-Riddle Aeronautical University-Daytona Beach

**Responsible Program:**

NASA Innovative Advanced Concepts

## Project Management

**Program Director:**

Jason E Derleth

**Program Manager:**

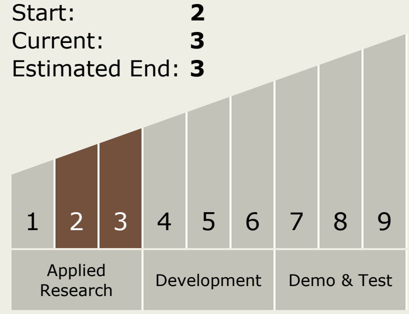
Eric A Eberly

**Principal Investigator:**

William Engblom

## Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



**June 2016:** Closed out

**Closeout Summary:** A baseline configuration for the dual-aircraft platform (DA P) concept is described and evaluated in a physics-based flight dynamics simulat ions for two month-long missions as a communications relay in the lower stratos phere above central Florida, within 150-miles of downtown Orlando. The DAP co nfiguration features two large glider-like (130 ft wing span) unmanned aerial ve hicles connected via a long adjustable cable (total extendible length of 3000 ft) which effectively sail without propulsion using available wind shear. Use of onbo ard LiDAR wind profilers to forecast wind distributions are found to be necessary to enable the platform to efficiently adjust flight conditions to remain sailing by f inding sufficient wind shear across the platform. The aircraft derive power from solar cells, like a conventional solar aircraft, but also extract wind power using t he propeller as a turbine when there is an excess of wind shear available. Month -long atmospheric profiles (at 3-5 min intervals) in the vicinity of 60,000-ft are derived from archived data measured by the 50-Mhz Doppler Radar Wind Profile r at Cape Canaveral and used in the DAP flight simulations. A cursory evaluation of these datasets show that sufficient wind shear for DAP sailing is persistent, su ggesting that DAP could potentially sail over 90% of the month-long durations e ven when limited by modest ascent/descent rates. DAP's novel guidance softwar e uses a non-linear constrained optimization technique to define waypoints such that sailing mode of flight is maintained where possible, and minimal thrust is re quired where sailing is not practical. A set of constraints are identified which res ult in waypoints that enable efficient flight (i.e., minimal use of propulsion) over the two month-long flight simulations. Waypoint solutions may need to be tabul ated for a wide range of potential atmospheric conditions and stored onboard for quick retrieval on a real DAP. DAP's flight control software uses an unconvention al mixture of spacecraft and aircraft control techniques. Flight simulations confir ms that this controls approach enables the platform to consistently reach succes sive waypoints over the month-long flight simulations. The ability of DAP to tran sition between the sailing mode (i.e., cable tension is high) and standard formati on flight (i.e., cable tension is low) is a vital capability (e.g., to enable intermitte nt turns while stationkeeping). A new method to perform these transitions has b een identified and characterized with flight simulation which requires special airc raft modifications. The energy-usage of the DAP configuration during two month -long stationkeeping missions over central Florida (i.e., stationkeeping over Orla ndo) is evaluated and compared to that of a pure solar aircraft of the same weig ht and aerodynamic performance. DAP is shown to consistently reduce net prop ulsion usage while simultaneously increasing solar energy capture. A baseline 70 0 GHz communications system is described and its performance evaluated for th e proposed mission over central Florida. It is found that the variable roll orientat ion of the aircraft would increase the power required to maintain coverage over the stationkeeping radius of 150 miles (e.g., by as much as 100% when DAP is 150 miles from Orlando), compared to level flight. This effect can be mitigated v ia additional antenna design complexity or a more restricted stationkeeping radi us. In summary, the results of realistic month-long flight simulations suggest th at the DAP concept may be a viable alternative to the pure solar aircraft as a str atospheric communications relay.

### Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

## Technology Areas

**Primary:**

- TX06 Human Health, Life Support, and Habitation Systems
  - └ TX06.3 Human Health and Performance
    - └ TX06.3.2 Prevention and Countermeasures

## Target Destination

The Moon